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Testosterone and the Incidence of Boar Taint: Effects of Testosterone or Testosterone Propionate on the Incidence of Boar Taint in Implanted Barrows

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SUMMARY

Boars, barrows and barrows implanted with testosterone or testosterone propionate via polydimethylsiloxane (Silastic) capsules were placed on test in individual pens at 10 weeks of age. Each animal was slaughtered at 110 kg and evaluated for growth rate, efficiency of feed utilization, carcass merit and the incidence of objectionable odors (boar taint). Five capsules of testosterone or testosterone propionate were used in barrows since they substantially elevated concentrations of serum testosterone, decreased serum LH and stimulated weights of the accessory sex glands. Large variations within and between litters of pigs were found for performance and carcass traits; thus, the influences of castration and testosterone replacement therapy on these traits were inconclusive. In contrast, the effects of castration and hormone treatment on the incidence of boar taint were more definitive. The incidence of boar taint was relatively high in boars, according to a consumer taste panel. This characteristic odor was appreciably lower in barrows and was not reinstated with either testosterone or testosterone propionate implants. These results suggest that testosterone is not itself responsible for boar taint and that 5α-androstenone, the pheromone most closely associated with boar taint, is not produced by peripheral metabolism of testosterone. Additional studies are warranted to provide insight into the regulation of testicular steroid secretion in the boar and the contribution of these steroids to boar taint and protein anabolism.

INTRODUCTION

Castration of male pigs at a few days or weeks of age to prevent the later development of objectionable male odors and flavors in pork is common practice. This practice carries with it a compromise of reduced rate of weight gain and efficiency of feed utilization and increased carcass fat (Walstra & Kroeske, 1968; Wismer-Pederson, 1968; Martin, 1969; Turton, 1969; Field, 1971; Seideman *et al.*, 1982). A substantial improvement in overall swine production economy and biological efficiency would result from the marketing of intact male pigs void or devoid of boar taint.

The unpleasant musk smell of 16-unsaturated steroids was first identified in testicular tissue from boars (Prelog & Ruzicka, 1944) and was later found to be present in high concentrations in adipose tissue (Patterson, 1968; Berry & Sink, 1971; Fuchs, 1971; Andresen, 1975*a*; Malmfors & Andresen, 1975). The pheromone, 5α-androstenone, which is the steroid thought to be most closely associated with boar taint (Booth, 1982), appears to be produced within the testes (Gower & Ahmad, 1967). Like testosterone, this steroid is secreted, in response to gonadotropic stimulation (Andresen, 1975*b*; Carlstrom *et al.*, 1975; Malmfors *et al.*, 1976), into the systemic circulation via the spermatic vein (Gower *et al.*, 1970; Saat *et al.*, 1972). Thus, a positive relationship exists between the secretion of 5α-androstenone and testosterone. Testosterone does not appear to contribute to boar taint via gonadal or extragonadal conversion to 5α-androstenone (Booth, 1982); however, testosterone may induce the production of other odors which consumers associate with boar taint. The present study was conducted to determine whether chronic exposure of barrows to physiological dosages of testosterone would induce objectionable odors in their carcasses. Parts of these data have been presented briefly elsewhere (Schanbacher *et al.*, 1983).

MATERIALS AND METHODS

Forty-eight male pigs (four each from twelve litters) were assigned at birth to one of two experiments. Experiment I comprised thirty-two pigs (eight litters), whereas experiment II comprised the remaining sixteen pigs (four litters). For each experiment, littermates were randomly assigned to one of four treatment groups. Group 1 pigs were left as intact boars, group 2

were castrated at birth, group 3 were castrated at approximately 45 kg body weight and group 4 pigs also were castrated at 45 kg body weight but simultaneously given testosterone (experiment I) or testosterone propionate (experiment II). Steroids were provided by five polydimethylsiloxane (Silastic) capsules (30 cm × 4·65 mm outside diameter × 3·35 mm inside diameter) placed just over the ribs under aseptic conditions via a surgical trocar according to procedures described for testosterone treatment of lambs (Schanbacher, 1980; Schanbacher *et al.*, 1980). In a preliminary experiment, these capsules were found to provide physiological concentrations of serum testosterone, to decrease serum LH concentrations (Fig. 1) and to stimulate weights of the accessory sex glands in growing–finishing barrows weighing 70 kg.

Litters were weaned at 4 weeks of age and maintained as a unit on a

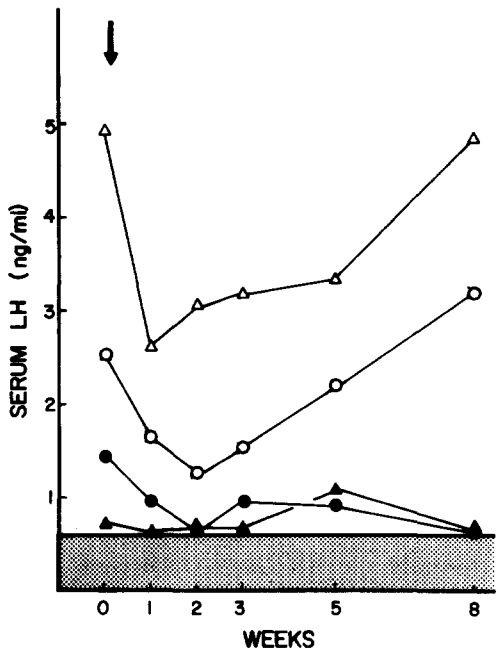

Fig. 1. Serum LH concentrations in intact boars and barrows given testosterone via subdermal polydimethylsiloxane implants (preliminary study). Two sham-treated intact boars (—●— and —▲—) had low, relatively stable, serum LH, whereas barrows given three implants (—○—) or six implants (—△—) had their elevated serum LH reduced by approximately 50% after 1 or 2 weeks of steroid exposure. The subsequent rise in serum LH was thought to be a response to decreasing concentrations of serum testosterone. The arrows denotes the time at which implants were administered and the shaded portion the sensitivity of LH radioimmunoassay.

weaning diet for an additional 6 weeks. Pigs were then placed in individual feeding pens at approximately 20 to 25 kg (period 1) and fed a 16% protein corn–soybean meal grower diet *ad libitum*. Treatments were imposed on pigs in groups 3 and 4 at 45 kg body weight and performance traits were monitored for the next 18 days (period 2). Animals were slaughtered at the end of period 3, when individual weights of approximately 110 kg were attained. Blood samples were collected from each pig at the end of each period.

Animals in groups 1, 2 and 3 were slaughtered at the MARC abattoir, where selected carcass traits and accessory sex gland weights were collected and recorded. Group 4 animals were slaughtered locally for the same information. Before these carcasses were disposed of, implants were recovered and checked for possible damage. A loin chop with external fat also was collected and subsequently analyzed by a consumer taste panel for incidence of boar taint.

Six men and six women were asked to score separately a heated fat and muscle sample for objectionable odor(s). A six-point system was arbitrarily chosen wherein: 1 = no objectionable odor, 2 = trace odor, 3 = slight odor, 4 = distinct odor, 5 = strong odor and 6 = very strong odor. The scores were tabulated and means determined for each fat and muscle sample.

Serum luteinizing hormone (LH) concentrations were determined by double antibody radioimmunoassay as previously described (Ford & Schanbacher, 1977). LER-786-3 was used as the porcine LH standard and assay sensitivity was 0·6 ng per millilitre of serum. Testosterone concentrations were quantified in diethyl ether extracts of 200 μl of serum (Schanbacher, 1982). The antiserum (X-181) produced in rabbits against 19-O-carboxymethyl ether BSA (Rao *et al.*, 1978) was used at a working dilution of 1:40 000. The antiserum was quite specific for testosterone and cross-reacted minimally with dihydrotestosterone (7%) and 5α-androstenone (< 1%). Sensitivity of the assay was 10 pg and the intra-assay coefficient of variation for a serum pool containing 1 ng per millilitre of testosterone was 8·5%.

Data were analyzed by least-squares analysis of variance (Harvey, 1975); the model used included the main effects of treatment and litter. Initial weight and days on feed were included as linear covariates for all analyses except those for growth and feed conversion efficiency. Where significant, group means were separated by Duncan's new multiple-range test.

RESULTS

Polydimethylsiloxane capsules filled with testosterone or testosterone propionate provide a simple, convenient way of maintaining elevated concentrations of serum testosterone. Implanted barrows in the preliminary experiment had reduced serum LH (Fig. 1), and those in experiments I and II had increased weights of the accessory sex glands (Table 1), and serum testosterone concentrations similar to those found in young boars (Table 1). Whereas castration at birth (early castrates; group 2) and at 45 kg body weight (late castrates; group 3) resulted in extremely low serum testosterone, concentrations increased steadily in intact boars throughout the study. Implanting caused an immediate rise in serum testosterone which peaked at 1·6 ng/ml (testosterone implanted group; experiment I) and at 6·2 ng/ml (testosterone propionate group; experiment II) during period 2. Mean testosterone levels declined gradually

TABLE 1

Serum Testosterone, Accessory Sex Gland Weights and Incidence of Objectionable Odors (Boar Taint) in Boars, Barrows and Barrows Given Testosterone (Experiment I) or Testosterone Propionate (Experiment II)

Group	*Serum testosterone (ng/ml)*	*Seminal vesicle*	*Prostate*	*Bulbo-urethral*	*Boar taint*[c]	
			(g)		*Fat*	*Lean*
Experiment I:						
Boars	3·25[d]	307[d]	10·1[d]	194[d]	4·4[d]	3·4[d]
Barrows[a]	0·12[e]	2[e]	6·0[e]	9[e]	2·3[e]	2·2[e]
Barrows[b]	0·16[e]	5[e]	0·8[e]	18[e]	2·5[e]	1·8[e]
Barrows + T	0·55[f]	195[d]	5·6[f]	116[e]	2·9[e]	2·0[e]
Experiment II:						
Boars	3·75[d]	153[d]	7·2[d]	164[d]	4·0	2·4
Barrows[a]	0·11[e]	2[e]	0·5[e]	10[e]	3·7	2·6
Barrows[b]	0·18[e]	4[e]	0·7[e]	14[e]	3·5	2·2
Barrows + TP	4·81[d]	513[f]	11·5[d]	243[f]	3·5	2·7

[a] Castrated at birth.

[b] Castrated at approximately 45 kg liveweight. Testosterone (T) or testosterone propionate (TP) was administered via Silastic implants at the time of castration.

[c] 1 = No objectionable odor, 2 = trace of odor, 3 = slight odor, 4 = distinct odor, 5 = strong odor, 6 = very strong odor.

[d–f] Means without a common superscript within a column differ ($P < 0·05$).

TABLE 2

Growth Rate, Feed Utilization and Carcass Traits of Boars, Barrows and Barrows Given Testosterone (Experiment I) or Testosterone Propionate (Experiment II)

Group	*Average daily gain (g/day)*	*Feed/gain (kg/kg)*	*Final weight (kg)*	*Carcass weight (kg)*	*Carcass length (cm)*	*Backfat last lumbar (cm)*	*Loin eye area (cm^2)*
Experiment I:							
Boars	816	2·54	107·1	NR	84·1	$1·6^{c}$	$43·9^{c}$
Barrows[a]	748	2·82	108·4	NR	81·3	$2·3^{cd}$	$39·3^{d}$
Barrows[b]	794	2·51	108·4	NR	82·0	$2·5^{d}$	$40·6^{d}$
Barrows + T	748	2·66	105·7	NR	84·3	$2·0^{cd}$	$44·8^{c}$
Experiment II:							
Boars	939	$3·02^{c}$	116·6	83·9	84·8	$2·4^{c}$	$36·1^{c}$
Barrows[a]	853	$4·35^{d}$	109·3	80·3	81·8	$3·6^{d}$	$28·0^{d}$
Barrows[b]	907	$3·68^{cd}$	114·8	68·0	83·1	$3·1^{d}$	$26·6^{d}$
Barrows + TP	821	$3·45^{c}$	103·0	72·1	81·5	$2·8^{cd}$	$28·1^{d}$

[a] Castrated at birth.

[b] Castrated at approximately 45 kg liveweight. Testosterone (T) or testosterone propionate (TP) was administered via Silastic implants at the time of castration.

[c–d] Means without a common superscript within a column differ ($P < 0·05$).

NR = not recorded.

thereafter. Higher release rates from testosterone propionate capsules resulted in higher serum testosterone levels for this treatment group.

Growth rates (ADG) for the four treatment groups were similar in both experiments (Table 2). Feed conversion efficiency (feed/gain) for the four treatment groups favored boars in both experiments. Considerable inter- and intra-litter variation in performance traits was observed.

Carcasses tended to be shortest in non-implanted barrows and longest for boars but these differences were not significant (Table 2). Loin eye area, on the other hand, was greatest in boars and implanted barrows and least in non-implanted barrows. Barrows had more backfat than boars whereas implanted barrows had intermediate backfat thickness. Therefore, measures of carcass merit showed general relationships to sex (hormonal) condition with backfat thickness being most closely coupled to circulating androgen levels.

Results of the panel evaluation for the presence of objectionable odors (boar taint) are shown in Table 1. Samples of fat and lean from boar

carcasses scored highest for boar taint with little difference detected between implanted and non-implanted groups. Whereas the absolute scores for a given sample differed among panel members, the actual ranking of samples was usually the same. The ranges of scores, within treatment groups, were: (1) for heated fat samples, 3·1 to 5·1 for boars, 1·6 to 4·4 for implanted barrows and 1·5 to 4·5 for non-implanted barrows and (2) for heated muscle samples, 1·5 to 3·7 for boars, 1·2 to 3·6 for implanted barrows and 1·2 to 3·1 for non-implanted barrows. The overall simple correlation between fat and muscle odor scores was 0·67 ($P < 0·01$).

DISCUSSION

The objectionable odor or taint associated with heated pork or pork fat of intact boars is well recognized and remains a costly problem for the swine industry. Although the effects of castration on growth rate and feed utilization are not as well established for pigs as they are for sheep and cattle, an economic advantage of producing pork from intact boars is claimed (Field, 1971; Seideman *et al.*, 1982). If 3% more lean could be produced from boars than from barrows (Wismer-Pederson, 1968; Martin, 1969), a no-castration policy would result in a substantial increase in the weight of pork lean produced annually.

To avoid the necessity of supplementing the growing–finishing castrate with anabolic hormones, producers should take advantage of the anabolic hormones produced by the testes. Testosterone is thought to be the most important of these hormones (Schanbacher *et al.*, 1980), but the close relationship between testosterone production and the production of the putative steroid responsible for boar taint, 5α-androstenone (Booth, 1982; Williamson & Patterson, 1982) makes pork production by intact boars doubtful. Argument against a tight coupling of testosterone and 5α-androstenone secretion has been made by Gower (1972) and it is this argument which has stimulated the selection of boar lines with high and low 5α-androstenone levels (Willeke *et al.*, 1980).

We have shown that physiological concentrations of testosterone do not induce the characteristic boar taint in carcasses of barrows. Administration of testosterone to barrows may have a positive influence on carcass merit (carcass length, loineye area and backfat thickness, in particular); however, definitive conclusions cannot be made about the

effects on growth and performance traits. If testosterone promotes protein anabolism, as has been suggested, attempts to separate the secretory capabilities of the testes into anabolic hormones and pheromones are warranted. Many investigators have set up assay procedures by which to study the physiology of 5α-androstenone production (Gower *et al.*, 1970; Claus *et al.*, 1971; Andresen, 1975*a*; Booth, 1975; Carlstrom *et al.*, 1975) and to use as a basis for carcass discrimination at slaughter time (Andresen & Bakke, 1975; Kaufman *et al.*, 1976); on the other hand, few have attempted to regulate its secretion. Preliminary findings have been reported by Brophy & Gower (1974) and Kaufman & Schubert (1980). An alternative approach to specific inhibition of 5α-androstenone production which has been recently evaluated involves immunological suppression of circulating 5α-androstenone (Claus, 1975; Williamson & Patterson, 1982).

In conclusion, this study demonstrates that physiological concentrations of testosterone do not induce boar taint in barrows. Additional studies with intact boars as growing–finishing animals are warranted to determine means of exploiting their efficient production potential.

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